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The Brown Bark Spot of
Fruit Trees

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The Brown Bark Spot of Fruit Trees

A few years ago there appeared in certain orchards of this State a new disease of fruit trees, so distinctive in appearance and so destructive in its effect on the trees that it commanded the immediate attention of this experiment station. Continuous work has been carried on with this disease, and although the investigations are not complete the appearance of the disease in other localities and the demand of our own fruit growers for the information we have accumulated warrant a bulletin on this subject at this time.

HISTORY OF BROWN BARK SPOT

In the summer of 1907 a fruit grower near Columbia Falls, Montana, sent to this experiment station a few apple twigs, accompanied by a letter stating that the disease on the bark caused a defoliation of the trees. The twigs showed only a few insignificant-looking spots and as no one in either the botanical or the horticultural department had ever noticed such a disease in his travels over the State the matter was not given serious consideration. During the next two years trees were seen in other orchards in the western part of the State that were probably affected by this disease in a form not quite typical.

The serious possibilities of the disease were first impressed upon the writers in 1910 during a trip to Rollins Bay on the west shore of Flathead Lake. Here it was present in typical form, trees being killed outright in one to two years from the time of attack, or lingering longer in some cases. Because of the distinctive appearance of the spots and to distinguish this disease from others affecting the bark of fruit trees, the name "brown bark spot" was given by us. Since 1910 the disease has appeared in certain localities all over western Montana. We have had it under investigation for more than ten years.

GEOGRAPHICAL DISTRIBUTION

It is difficult to give the distribution of this disease because of the uncertainty of its diagnosis. If the cause were a definite organism, easily found, the presence of this organism could serve for positive identification even in otherwise doubtful cases. Such

is not the case, however, and we are obliged to rely upon symptoms alone for diagnosis. In many cases these are so definite and distinctive that there can be no doubt. In others, however, especially the milder ones, there is a possibility of error.

In Montana.—Brown bark spot has not been found east of the Continental Divide. West of the divide its distribution is quite general, though there are some large areas free from it. In Flathead County typical cases may be found scatteringly from Columbia Falls south to Flathead Lake. On the east shore of the lake there is little or none. On the west shore it is most abundant around Rollins Bay. In the Bitter Root Valley the disease appears in spots in the upper (southern) half while the lower half is relatively free from it. In the vicinity of Thompson Falls we have found what seems to be a mild form of it.

The disease often appears in irregular patches in an orchard though isolated trees are not uncommon. It is not confined to any one slope, type of soil, or system of orchard management.

Outside of Montana.—Brown bark spot is known to be present in certain parts of Washington and probably in Oregon and Idaho. We can not learn that it occurs east of the Rocky Mountain region.

A recent interesting development is its probable occurrence in Japan. In January, 1920, Dr. K. Nakata, of the Kiushiu Imperial University, Fukuoka, Japan, submitted to us samples of apple twigs from Japan that were strikingly like those affected with the disease in this State, and we submitted to him specimens in return. While the diagnosis could not be positive yet we feel certain that the disease in the two countries is identical. Doctor Nakata states, "I am inclined to believe that the disease is probably the same as that in Japan. Although the symptoms are slightly different, that may be attributed to the variety attacked."

The fact that fifteen years ago brown bark spot was unknown and that ten years ago it did not occur in several regions where it is now prevalent indicates that it is likely to extend still farther.

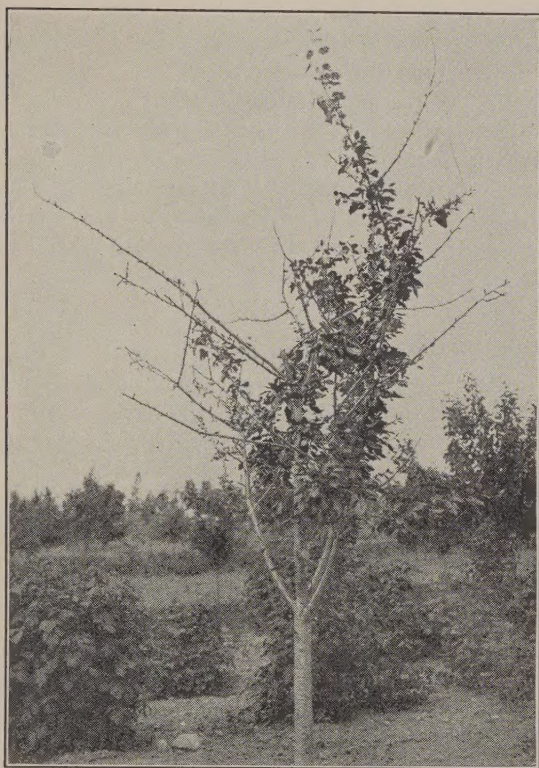


Fig. 1.—Apple tree showing the advanced stages of the brown bark spot disease.

TREES AFFECTED

The trees that are most damaged by brown bark spot are apple and pear, though it has been observed also on plum, prune, peach, and cherry. It has not been found on native trees and shrubs, such as poplar, willow, dogwood, service berry, and hawthorne, although these are present in the same localities.

Of the apples most standard varieties are apparently susceptible. We have observed it on Alexander, Baldwin, Black Gilliflower, Delicious, Gano, Jonathan, Lawver, McIntosh, Northern

Spy, Northwestern Greening, Oldenburg, Scott, Wealthy, Wolf River, and Yellow Transparent, and have not found any resistant standard variety growing among the affected ones. The Transcendant (crab) seems practically resistant.

Pears, peaches, plums, prunes, and cherries are not extensively grown in Montana, but from our observations we would judge that the pears, at least the Bartlett and Flemish Beauty, are extremely susceptible. The stone fruits, however, are much more resistant, so much so that the disease has done serious damage in only a few instances.

SYMPTOMS

Brown bark spot is chiefly characterized by (1) death of buds on certain branches and consequent failure to leaf out (fig. 1), (2) elevated brown spots on the bark, and (3) death of portions above ground, the bark being the principal seat of the disease. As these symptoms vary considerably in the different species of fruit trees they will be discussed for the apple, the pear, and the stone fruits.

Symptoms on apple.—The disease makes its first appearance in the spring with the swelling and opening of the buds. Up to this time a tree may seem perfectly normal, even upon the closest inspection. As the buds swell those on certain shoots may remain smaller than the others, and as the normal ones open these small diseased ones shrivel and die (fig. 2). In other cases the affected buds open with the others or a few days later and then die, leaving little clusters of shriveled leaves and perhaps flower buds. Sometimes the killed buds adhere tightly to the tree, but in other cases, especially common in the spring of 1915, they loosen so that a vigorous shake will bring them down in large numbers. The affected buds may be confined to a single shoot or small branch, or may include all those on a large branch or even an entire tree. The buds that die without opening show a conspicuous dark brown streak running down through the center to the base where it attaches to the branch. This discoloration usually begins as a tiny spot in the growing point and a few days later extends down to the base of the bud as a streak. Frequently the bark close around the bud dies and becomes sunken (fig. 2). (For comparison with winter injury see page 20.) Often the

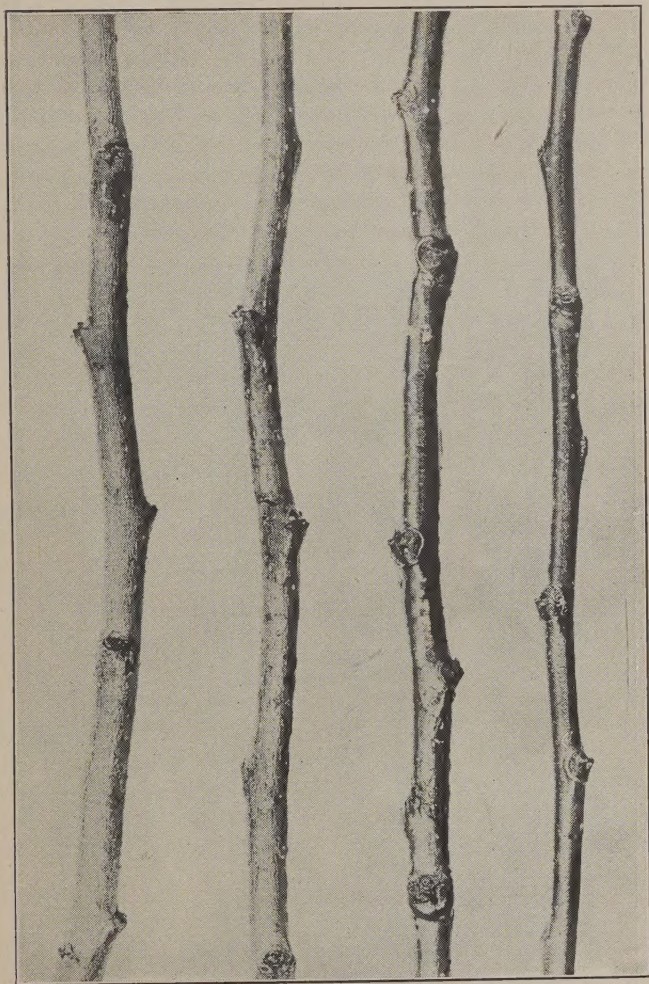


Fig. 2.—Apple twigs showing the failure of buds to produce normal growth and leaves

fibro-vascular bundles that run from the leaf scars through the bark to the cambium are nearly black.

At the time the symptoms are first noticeable in the buds all other parts of the tree, including even the bark close to them, look perfectly normal. A week or two later, however, small spots shaped like pimples begin to develop on the bark of the youngest shoots (fig. 3). These are quite small—about one-eighth inch in diameter at the base and perhaps one-sixteenth inch high with pointed top. On older branches these spots are correspondingly



Fig. 3.—Twigs showing the small spots or the pimple stage of the disease.

larger, being one-fourth inch to three-eighths inch across at the base on branches three-fourths inch in diameter. These larger spots are less pointed at the top. Spots of this character do not ordinarily appear on limbs that are an inch or more in diameter. These spots are of the normal color of the bark at first, but soon the central portion takes on a green, water-soaked appearance and then turns a dull brown extending down to the cambium layer. These pimple-like spots may be very few in number and several inches apart or very numerous, in fact almost touching each other in some cases. Soon the bark on the smallest affected shoots turns brown, shrivels, and dries, but that on branches one-half to three-fourths inch in diameter may remain alive and green for several weeks, without, however, producing any growth from latent or adventitious buds. Branches thus affected are almost sure to die. Cases of recovery are very rare.

Some weeks after the killing of the buds and the appearance of the small, pimple-like spots there develop on the larger branches and even on trunks up to five inches in diameter the typical brown spots that characterize this disease (fig. 4.) These spots are nearly circular and vary in diameter from one-half inch to three inches. They are elevated one-sixteenth to one-eighth inch, the elevation being rather abrupt at the margins and nearly flat on top. The color of the outside is usually a reddish brown with practically none of the green found on the surrounding bark. The color inside is at first mottled, pale green and brown, and later entirely brown to the cambium. Late in the season the spot often cracks away from the surrounding bark (fig. 5). These brown spots have a rather spongy texture not so firm as the surrounding bark.

It may be that some of these brown spots develop by enlargement of the pimple-like spots described above. That such is the case on branches three-fourths to one inch in diameter is indicated by the fact that all gradations can be found between the two kinds of spots. On larger limbs and small trunks the pimple-like spots are not found and the brown spots appear to develop independently.

Above these brown spots the limbs and branches may be entirely leafless, while in other cases some of the branches will

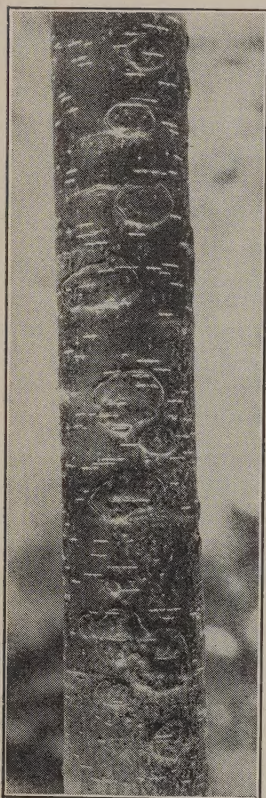


Fig. 4.—Trunk of apple tree showing a number of the larger spots. One-half natural size.

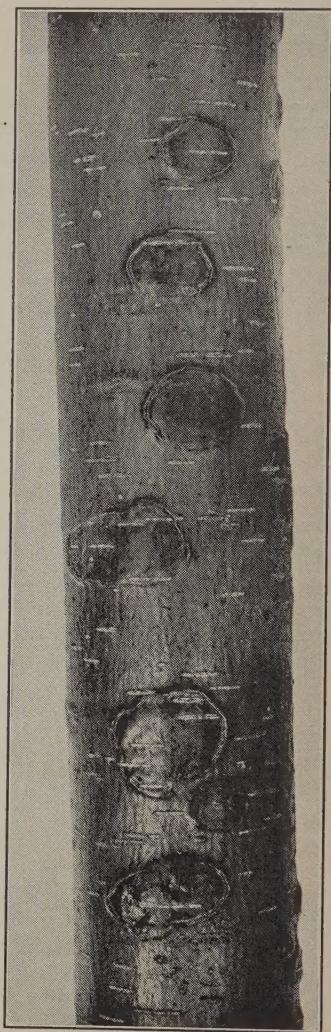


Fig. 5.—Trunk of apple tree showing the cracking around the spots in the fall. One-half natural size.

be leafless while others bear a full crop of leaves and are apparently normal (fig. 1).

The bark dies progressively from the tips of the branches downward. By peeling it off, red-brown streaks can usually be seen in the cambium and inner bark far in advance of the discoloration and shriveling of the outer bark. In some cases only the tips of a few branches are killed, in others all the branches on one or more large limbs, while not infrequently young trees are killed to within a few inches of the ground in a single season. In these worst affected trees not a single bud put forth leaves in the spring, and by midsummer practically the whole top was dead. As a rule, however, the tree dies back to the lowest brown spot or a little farther. There are some exceptions, in which shoots are put forth higher up and the brown spots peel off as scales a few years later and a partial recovery is thus effected.

The bark of the root system is singularly free from discoloration, spots, or other symptoms, and not infrequently latent or adventitious buds start from the trunk just above the ground. When the roots die it appears to be as an indirect result of the death of the top—in other words, a starvation due to the lack of leaves to manufacture carbohydrates. The susceptible portions of the tree are the buds and the bark of the branches and trunks. The wood and the bark of the roots are the last to die.

Symptoms on pear.—Pear trees generally show even more susceptibility to brown bark spot than apple trees, judging by the rapidity with which it extends down an affected tree.

In many ways the symptoms and course of the disease correspond with those in the apple, and therefore only the differences will be noted. (See fig. 6).

Externally there appear on the bark, after the death of the buds, both the small and the large spots, but the color of the large ones is not brown but a dull, dark gray, sometimes nearly black.

The discoloration of the inner bark is very striking. This discoloration, instead of being reddish brown as in the apple, is almost black. Often the cambium region of limbs one-half to two inches in diameter is blackened in streaks one to three feet long and the discoloration extends outward half way through the bark as a mottling, the black mingling with the normal whitish color.

This darkening of the inner bark takes place days or even weeks before the bark shows any shriveling or change in color on the outside.



Fig. 6.—An advanced case of the disease on pear, resulting in the death of the tree.

It should be remarked here that the difference in color of the affected bark of pear and of apple is not peculiar to this disease; for if the bark or leaves of pear are killed by almost any agency—blight, fire, or arsenical injury, for example—they become much blacker than corresponding parts of apple killed in

the same way, the dead apple tissue being always a much redder brown.

Stone fruits.—With respect to dying of the buds and failure to leaf out, plum and cherry trees behave like apple and pear when stricken with brown bark spot. There is also a similar spotting of the bark, but externally these spots are not nearly so conspicuous because of the fact that the normal bark is a shade of brown similar to that of the spot. Likewise the interior of the healthy bark of these stone fruits is not so light colored as that of pear and apple, so that while a discoloration exists similar to that described for apple this is not quite so noticeable as in apple and not nearly so noticeable as in pear.

DAMAGE DONE

From the standpoint of the individual tree no disease is more rapidly destructive than brown bark spot. Not infrequently trees that in April appeared perfectly healthy are killed to the ground by late summer. Fortunately the disease does not spread from tree to tree as does blight and the total number of cases in any community usually is not high. Still we have known instances where this disease has been the chief cause for the removal of some orchards, and we have seen many other orchards greatly damaged by it. Only a little calculation is required to show that the removal of five to ten per cent of the trees from a bearing orchard is a serious matter.

THE CAUSE OF BROWN BARK SPOT

The appearance of the large brown spots on the bark and the discoloration of the inner bark are of a character to suggest at once the work of a pathogenic organism. To one familiar with diseases of the bark of fruit trees it looks like a simple proposition to demonstrate the presence of such organisms by the methods given below. We started the investigation confident of early success in demonstrating the cause of the disease. We soon found this assumption to be an error.

There are several methods that may be used individually or collectively to ascertain whether or not a plant disease is infectious and transmissible to other plants. The most important of these are (1) microscopic examination of the diseased tissues; (2) isolation of pure cultures of the causative organism, if such

there be, and culture of this organism in the laboratory; and (3) inoculation of healthy plants, preferably with pure cultures of the organism isolated from a diseased plant; but if no pure culture has been obtained, inoculation by cutting out a bit of diseased tissue and inoculating it directly into the healthy experimental plants. By these methods, executed in a variety of ways to suit the occasion, it has been ascertained with regard to nearly every known plant disease whether or not it is transmissible. In most cases the exact cause of the disease has thus been ascertained. In addition to these very common methods other special ones may be resorted to in very difficult cases to make an ordinary investigation more complete. As practically all known methods have been used to determine the cause of brown bark spot these experiments and observations will be briefly described.

Examination of diseased tissues.—While the discoloration following the death of parts is very conspicuous, as described under the topic of symptoms, no pustules, as of a fruiting fungus, are visible to the naked eye until long after that part of the bark is dead. Then organisms of decay sometimes make their appearance as they do in any dead bark, regardless of the cause of death.

Much attention has been given to a microscopic study of the dying buds, the spots on the branches, and the discolored inner bark. In the field and in the laboratory freshly cut specimens have been studied as free-hand sections, unstained. These examinations were continued at intervals for eight years, both the authors of this bulletin taking part, and at times other interested persons.

Realizing that the organisms might be too transparent to be seen in the natural tissues, various stains have been employed to make them visible. In addition to the work we have done ourselves this problem was made the subject of a special investigation by Mr. R. A. Studhalter, who was employed in this department during the winter and spring of 1917.

During all this time there was not found in a single instance any indication of a fungous or bacterial invader. The living cells of the bark, fairly normal in appearance, abutted directly on others in various stages of disintegration with nothing to indicate the cause of death. The various changes that had taken place in the dead cells need hardly be recorded here.

The negative results of this method of microscopic examination, while strongly suggestive of the absence of a parasite, are not conclusive, for we are aware that in crown gall* and in the mosaic disease of various plants no parasite has been seen in the tissues, though the infectious nature of these diseases has been fully demonstrated. We consider this line of work but a link in a chain of evidence.

Cultural work.—Most persistent efforts have been made to get from the diseased tissues a growth of a causative organism on artificial culture media. The method most used was to disinfect the surface of the branch to be studied with a 1 to 1000 solution of mercuric chloride and then transfer bits of the diseased tissue from beneath the surface to tubes of melted beef agar or apple-bark-infusion agar and then pour the agar and pieces of bark into sterile petri dishes. Where these cultures were from the discolored inner bark the surface of the bark was disinfected with mercuric chloride and when nearly dry a gash was cut through it to the cambium with a hot sterile scalpel. With hot sterile forceps the bark was stripped off from this gash downward for an inch or more, exposing discolored tissue that had not been touched by the disinfectant or by any instrument. With a cold sterile scalpel bits of this discolored tissue were transferred to the melted agar and poured out as described above. Such cultures were made from all parts of the affected bark. Culturing from diseased buds is a little more difficult, but the method used was similar to that for the bark.

Cultures made in this way were incubated at different temperatures and watched for several weeks.

In most cases the cultures thus made remained sterile, developing no growth whatsoever. In some cases a few growths appeared of common molds or other saprophytic organisms, evi-

*Dr. Erwin F. Smith, after failing to demonstrate bacteria in crown gall by the use of anilin dyes, resorted to the rather unusual method of impregnating with gold chloride. By this means he made visible certain bodies in the cells that look strikingly like bacteria and were so considered by him. (Bureau of Plant Industry Bulletin 255, page 18.) In his recent book, however, (Bacterial Diseases of Plants, page 468, W. B. Saunders & Co.) he raises a question if there is not "at least a strong probability" that these bodies "are only normal constituents of the plant cell."

dently intruders that gained access in the process of culturing. In some cultures made from bark that had been dead for quite a long time common molds appeared in abundance, indicating that they were growing in the old dead bark. Not in a single case was there obtained anything approximating a pure culture of an unfamiliar organism that might have been responsible for the disease. In a few doubtful cases cultures of the organisms obtained were used to inoculate healthy apple trees. A small incision was made in the bark or at the base of buds and the organisms to be tested were inserted, after which the wound was covered with moist cotton or waxed cloth. No disease of any kind developed as a result of any of these inoculations. Indeed the fact that the great majority of the bits of discolored tissue put into the culture media developed no growth whatsoever made it seem highly probable that no living germ exists in the tissues recently killed by this disease. In animal and human pathology, to be sure, some pathogenic organisms are encountered that will not grow on ordinary laboratory culture media, but such is not the case with bacteria causing plant diseases. In practically all cases the causative organism will grow in either beef agar or an infusion of the juices of the host plant, usually both. To be sure some of the fungi, as mildews and rusts, do not thrive on such artificial culture media, but their presence could hardly have been overlooked in microscopic examination.

It should be emphasized that these cultures were not limited to a few trials. Actually hundreds of cultures were made from apple, pear, and cherry, for we were at first strongly of the belief that the disease was caused by an organism. Some variations of method and culture media were used but without encouraging results.

Even this we do not regard as positive proof that brown bark spot is not an infectious disease, for at least one other group of diseases known to be transmissible, namely, mosaic diseases, has proved refractory to cultural methods.

Inoculation of healthy trees.—While the plant pathologist prefers, as a rule, to make his inoculations with pure cultures of the suspected organism, he sometimes finds it expedient to use instead bits of diseased tissue or juices from a diseased plant. These have been found pretty reliable in reproducing many dis-

eases, even mosaic diseases where microscopic examination and cultures have failed.

As previously stated, some few inoculations have been made in healthy trees with pure cultures obtained from diseased trees, but it was believed at the time that these organisms were not primarily responsible for the brown bark spot, and the fact that all these inoculations failed gave strength to this belief. As it is of prime importance to know whether or not brown bark spot is caused by an infective agent and hence transmissible to other trees, the method of direct tree-to-tree inoculation was used.

In the selection of material for this purpose bits of diseased bark were taken from spots of all kinds and sizes, sometimes from the center of the spot, sometimes from the margin, sometimes from the cambium region, and sometimes from the surface. Likewise, bits of tissue were taken from dead and dying buds. These were transferred directly to incisions cut in the bark of healthy trees, sometimes at the buds and sometimes in other places. In most cases, but not all, the inoculation wounds were wrapped with strips of cloth soaked in melted grafting wax to prevent drying. These inoculations were made in branches of every size from an inch in diameter down to the youngest shoots on the tree. Apple and pear were used mostly in this inoculation work but a few trials were made with cherry. This work was carried on in the months of April, May, and June.

Regardless of time or circumstance, the results of these inoculations were the same. The inoculated wounds healed with about the same rapidity as did similar wounds in which had been placed bits of healthy bark for comparison (checks or controls). In a few cases the bit of bark inserted in the wound decayed or molded and thus delayed the healing a little, but this occurred occasionally both in the inoculations and in the checks. Inoculations made in buds often killed them, but this was to be expected, considering the size of the wound, which was generally made with the point of a knife.

In not one of the inoculated branches did brown bark spot appear. The trees selected for inoculation were mostly either in orchards entirely free from this disease or in parts of the orchard free from the disease at that time.

Again we realize the possibility that failure may have been due to the method of inoculation or to the inoculation's having been made too late in the season, but we regard this evidence as stronger than any other used that brown bark spot is not caused by an infective agent.

Evidence of spread.—Considerable attention has been given to the distribution of affected trees in the orchards with a view to determining whether or not the disease spreads from the first trees stricken to others. As a rule the new cases that appear during a season all begin to show symptoms about the same time. Within two or three weeks from blooming time nearly all the trees that will show the disease that year can be recognized by dead buds and leafless branches. From that time on until the next spring few new cases appear. If there is a spread from tree to tree it is confined to a very brief period. As a rule the affected trees are in irregular groups of three or four to a dozen, but isolated cases are not unusual. This grouping may be due to infection from one spot or to an unfavorable soil in that region. It could hardly be a climatic effect. Sometimes the affected trees are in the lower part of the orchard and sometimes in the higher. Reports on the chemical composition of the soil are not yet complete and will not appear in this publication.

Spraying.—Spraying without knowing what the spray is supposed to kill or what mixtures to use or when to apply them can hardly be classed as a scientific procedure. To leave no stone unturned, however, some experimental spraying was done. A block of trees having the disease in small branches only was sprayed with lime-sulphur sp. gr. 1.035 in October, 1914, and again in April, May, and June, 1915, with lime-sulphur sp. gr. 1.015. New cases in mild form appeared during the spring of 1915, the number being about equal in this sprayed block and in adjoining unsprayed blocks.

A little spraying was done with lime-sulphur and with Bordeaux mixture in a block of badly affected old trees, but this apparently had no effect.

We have in addition, however, made some field observations on trees sprayed at various times of the year for the control of apple scab and oyster shell scale and have seen no reason to

believe that brown bark spot was lessened thereby. This spraying was all done with lime-sulphur.

Removal of buds.—Early in this investigation it was noted that the first visible symptom was a killing of the buds, and that the spots and the killing of the bark followed later. The question naturally arose whether possibly the whole trouble might not be due to the death of all the buds of all kinds on a branch by some agent capable of attacking buds only. In an effort to duplicate this condition artificially all buds were mechanically removed from certain branches before they opened in the spring. Before long latent or adventitious buds developed to take their place, but before they came into leaf they were removed. This was kept up all summer, and not until late August did the trees cease to make new buds on these branches. The bark at that time was still alive in most cases, and in all cases free from any spots resembling those of brown bark spot.

Top-working.—It has often been seen that after branches have died back for a certain distance from this disease vigorous shoots may start just below the line between live and dead bark. However, there is little tendency for new growth to start on small branches or shoots where all the buds have been killed, such as occurs when buds are removed by mechanical means. To determine whether or not these affected branches can support growth, some top-working was done by grafting and budding. It was found difficult to make buds and scions grow in affected bark but in a few cases good healthy shoots were thus obtained. Data on these extended over only one year.

It may be noted here that throughout this investigation much difficulty was encountered and some experiments lost by the removal of orchards by discouraged owners, who did not give us warning of their intentions.

Climatic conditions.—Throughout this investigation we have kept in mind the possibility that the whole trouble may be due to climatic conditions. We have no accurate weather records taken from the immediate vicinity of the affected orchards, and as the weather in these mountainous sections varies so much within short distances the records taken at the nearest United States Weather Bureau stations are hardly applicable. Furthermore, it is possible that the unfavorable condition happened in

so brief a space of time or was of such a nature that the usual weather records would not have shown it even had they been taken in the orchards in question.

The winter of 1914-15 caused considerable injury to fruit trees in Montana, and while making studies of brown bark spot in the spring of 1915 our attention was sharply called to certain similarities between the early symptoms of this disease and winter injury. Therefore a very close study was made of the winter injury to fruit trees in parts of the State where brown bark spot has never occurred, and the following points of difference were noted: (1) The wood and pith of winter-injured twigs and branches are distinctly browner than normal, while in those affected with brown bark spot they are of normal color up to the time the bark begins to shrivel. (2) In leaf buds killed by freezing, the discoloration does not begin conspicuously at the growing point (see page 6) and mildly injured buds show much more tendency to recover. (3) The characteristic spots of brown bark spot do not appear on branches killed by freezing alone. Of course there may be complications of the two forms of injury.

The outstanding evidence that the weather is not responsible for brown bark spot is this: It is a known fact that certain orchards and entire valleys were free from the disease prior to about 1910, and that since that time there has not been a single year that new cases have not appeared. If there is a weather condition that has recurred each year without fail for ten years, surely it would have visited these sections occasionally before that time, and quite likely it would occasionally have occurred in other nearby orchards that have always been entirely free from this disease. Such a coincidence is too much to believe.

Soil conditions.—The one factor that has not yet been thoroughly investigated is the composition of the soil. As previously suggested, the physical texture of the soils in different affected orchards varies somewhat, but this does not prevent the possibility that some necessary compound is lacking or insufficient, or that an injurious substance is present in all. These soils are now being studied by the chemistry department of this station. Soil moisture may well be left out of consideration for the disease occurs on both irrigated and nonirrigated land, and in both wet and dry seasons.

Summarizing the evidence relating to the cause of brown bark spot, it would seem that our numerous investigations here demonstrate beyond a reasonable doubt that it is not contagious and is not caused by a parasitic organism. We are not aware of any investigation of a plant disease in which the subject was studied so thoroughly from so many angles without discovering the infectious nature of the disease if one was later found to exist. Largely from negative evidence and by a process of elimination we incline to the theory that brown bark spot is caused by some fault in the chemical composition of the soil.

CONTROL

To give intelligent suggestions for the control of a disease without pretty definite knowledge as to its cause is so difficult that it has rarely been done. It is for this reason that such strenuous efforts have been made to determine the cause, or at least to find out whether or not it is due to an infective agent. We feel that we can at least say that orchardists need not be concerned about the contagious nature of brown bark spot. Whatever the cause may be, one need not be afraid of its transmission from tree to tree. What to do to prevent its attack on healthy trees or to cure those already attacked are still unsolved questions. On the theory that it may be caused by infertility of the soil with respect to certain elements of plant food, we would recommend that more attention be given to building up the orchard soils.

That some of the soils in the affected regions are deficient in nitrogen or phosphorus, or both, has already been demonstrated. That these deficiencies may aggravate brown bark spot seems not unlikely. The benefits of cover crops have been demonstrated at the substation near Victor, as reported in Bulletin No. 114 of this experiment station. In view of these facts the best advice we can offer in this connection is to devote special attention to increasing the fertility of the soil.

Even though it be found practicable to control the disease by this form of soil treatment, it is likely that brown bark spot will continue to appear occasionally in orchards that have been neglected or kept too long under clean cultivation. Under these circumstances some of the trees already affected might be saved by simultaneous soil treatment and top-working.

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